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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>C01B 31/28</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 98/28227</b> <b>(43) International Publication Date:</b> 2 July 1998 (02.07.98)
<b>(21) International Application Number:</b> PCT/US97/22903 <b>(22) International Filing Date:</b> 15 December 1997 (15.12.97)  <b>(30) Priority Data:</b> 60/033,447 20 December 1996 (20.12.96) US  <b>(71) Applicant (for all designated States except US):</b> E.I. DU PONT DE NEMOURS AND COMPANY [US/US]; 1007 Market Street, Wilmington, DE 19898 (US).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> CICHA, Walter, V. [CA/US]; Apartment 2, 1610 North Broom Street, Wilmington, DE 19806 (US). MANZER, Leo, Ernest [US/US]; 714 Burnley Road, Wilmington, DE 19803 (US).  <b>(74) Agent:</b> HEISER, David, E.; E.I. du Pont de Nemours and Company, Legal Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US).		<b>(81) Designated States:</b> JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> PHOSGENE MANUFACTURING PROCESS  <b>(57) Abstract</b>  A process for producing phosgene is disclosed which involves contacting a mixture comprising carbon monoxide and chlorine (e.g., at about 300 °C or less) with carbon which (1) has a micropore to macropore ratio of 3.5 or less; (2) has a high degree of oxidative stability (i.e., loses about 16 % of its weight, or less, in the WVC Temperature Test as defined herein); and (3) has a minimum surface area of at least 10 m <sup>2</sup> /g. The use of this carbon having an active metal content of 1000 ppm or more is disclosed.		

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TITLE  
PHOSGENE MANUFACTURING PROCESS  
FIELD OF THE INVENTION

5 This invention relates to a process for the manufacture of phosgene by the reaction of chlorine with carbon monoxide in the presence of a carbon catalyst. More particularly, this invention relates to a process for the manufacture of phosgene with minimal production of the hazardous chemical, carbon tetrachloride.

BACKGROUND

10 The production of phosgene by the reaction of chlorine with carbon monoxide in the presence of a carbon catalyst is a well known process. The phosgene produced by this process will typically contain 400 to 500 ppm by weight carbon tetrachloride. This amount, evaluated on the basis of the total world-wide production of phosgene of about ten billion pounds ( $4.5 \times 10^9$  kg)  
15 corresponds to co-production of about 4 to 5 million pounds ( $1.8 \times 10^6$  kg to  $2.3 \times 10^6$  kg) of carbon tetrachloride with the phosgene.

Japanese patent publication (Kokoku) No. Hei 6[1994]-29129 discloses that the amount of carbon tetrachloride produced during the phosgene manufacturing process can be reduced (e.g., by about 50%) by using an activated  
20 carbon which has been washed with an acid and which contains a total of 1.5 wt. % or less of metal components comprised of transition metals, boron, aluminum and silicon.

A process for producing phosgene using carbon having an active metal content of less than 1000 ppm and a weight loss of about 12% or less in the WVC  
25 temperature test has been described (see U.S. Application No. 60/012,021 and International Application No. PCT/US96/17526).

Carbon tetrachloride has been of concern in connection with ozone depletion and global warming potentials. Therefore, there is an interest in developing phosgene processes in which the amount of carbon tetrachloride  
30 impurity is minimized.

SUMMARY OF THE INVENTION

A process for producing phosgene is provided which comprises contacting a mixture comprising carbon monoxide and chlorine with carbon. In accordance with this invention, the carbon (1) has a micropore to macropore ratio of 3.5 or  
35 less; (2) loses about 16% of its weight, or less, when sequentially heated in air for the following times and temperatures; 125°C for 30 minutes, 200°C for 30 minutes, 300°C for 30 minutes, 350°C for 45 minutes, 400°C for 45 minutes, 450°C for 45 minutes and finally at 500°C for 30 minutes; and (3) has a surface area of at least  $10 \text{ m}^2/\text{g}$ . Also, in accordance with this invention, the active metal

content of the carbon may be 1000 ppm or more. Typically the contact is at a temperature of about 300°C, or less.

#### DETAILED DESCRIPTION

5 The present invention relates to improving the production of phosgene produced by contacting carbon monoxide and chlorine with carbon. The improvement can be employed in connection with any of those carbon-based processes used commercially or described in the art (e.g., those processes disclosed in U.S. Patent Nos. 4,231,959 and 4,764,308).

10 Phosgene is commercially manufactured by passing carbon monoxide and chlorine over activated carbon. The reaction is strongly exothermic and is usually done in multitubular reactors to more effectively control the reaction temperature. Carbon monoxide is typically added in at least a stoichiometric amount (often in stoichiometric excess) to minimize the free chlorine content of the phosgene product.

15 As used in connection with this invention, the term "active metals" means metals included in the group consisting of transition metals of groups 3 to 10, boron, aluminum and silicon.

The carbon materials useful as catalysts for this invention are porous (i.e., a surface area of at least 10 m<sup>2</sup>/g) and contain both micropores and macropores.  
20 As used in connection with this invention, the term "micropore" means a pore size of 20 Å (2 nm) or less and the term "macropore" means a pore size of greater than 20 Å (2 nm). The total pore volume and the pore volume distribution can be determined by mercury porosimetry. The micropore volume (cc/g) is subtracted from the total pore volume (cc/g) to determine the macropore volume. The ratio  
25 of micropores to macropores is then easily calculated. The carbons used for this process have a micropore to macropore ratio of less than 3.5, preferably 2.0 or less.

The carbons used for the process of this invention also exhibit substantial weight stability when heated in air. More particularly, when heated in air at  
30 125°C for 30 minutes, followed by heating at 200°C for 30 minutes, followed by heating at 300°C for 30 minutes, followed by heating at 350°C for 45 minutes, followed by heating at 400°C for 45 minutes, followed by heating at 450°C for 45 minutes and finally followed by heating at 500°C for 30 minutes, the carbons employed for the process of this invention lose about 16% of their weight, or less.  
35 This sequence of time and temperature conditions for evaluating the effect of heating carbon samples in air is defined herein as the "WVC Temperature Test". The WVC Temperature Test may be run using thermal gravimetric analysis (TGA). Carbons which when subjected to the WVC Temperature Test lose about 16% of their weight, or less, are considered to be advantageously oxidatively

stable. Preferably the weight loss in the WVC Temperature Test is 10% or less, more preferably 5% or less.

Low active metal content carbons can be used to achieve low carbon tetrachloride formation (see International Application No. PCT/US96/17526).

- 5 Low active metal carbons include three dimensional matrix porous carbonaceous materials. For example, the porous carbonaceous materials of Examples C and D in International Application No. PCT/US96/17526 have been measured to have total pore volumes of about 0.58 and 0.90 cc/g, respectively, and micropore to macropore ratios of about zero. Three dimensional matrix porous carbonaceous  
10 materials are described in U.S. Patent No. 4,978,649, which is hereby incorporated by reference herein in its entirety. Of note are three dimensional matrix carbonaceous materials which are obtained by introducing gaseous or vaporous carbon-containing compounds (e.g., hydrocarbons) into a mass of granules of a carbonaceous material (e.g., carbon black); decomposing the carbon-  
15 containing compounds to deposit carbon on the surface of the granules; and treating the resulting material with an activator gas comprising steam to provide a porous carbonaceous material. A carbon-carbon composite material is thus formed.

- We have, however, discovered that when the above described micropore to  
20 macropore ratios and weight stability criteria are satisfied, then the carbon can contain 1000 ppm or greater by weight of active metals. More surprisingly, even the iron content can be greater than 1000 ppm by weight. Iron is known to accelerate carbon tetrachloride formation. Of note are embodiments where active metals are 2000 ppm or more.

- 25 Carbon from any of the following sources are useful for the process of this invention; wood, peat, coal, coconut shells, bones, lignite, petroleum-based residues and sugar; provided that they are treated, if necessary, to reduce the micropore volume. Commercially available carbons which may be used in this invention include those sold under the following trademarks: Calgon X-BCP and  
30 Calsicat. The carbon support can be in the form of powder, granules, or pellets, or the like.

The carbon surface area as determined by BET measurement is preferably greater than about 100 m<sup>2</sup>/g and more preferably greater than about 300 m<sup>2</sup>/g (e.g., from 550 to 1000 m<sup>2</sup>/g). Typically, surface areas are 2000 m<sup>2</sup>/g or less.

- 35 It is known from dissociation equilibria that at 100°C, phosgene contains about 50 ppm chlorine; and that at 200°C, about 0.4%, at 300°C, about 5% and at 400°C about 20% of the phosgene is dissociated into carbon monoxide and chlorine. Also, the higher the reaction temperature, the more carbon tetrachloride is generally produced. Accordingly, the temperature of the reaction is generally

about 300°C, or less (e.g., in the range of from 40°C to 300°C). Preferably, the temperature of the process is from about 50°C to 200°C; more preferably from about 50°C to 150°C. The phosgene produced by the process of this invention typically contains about 350 ppm by weight or less of carbon tetrachloride, based upon phosgene (i.e., 350 parts by weight CCl<sub>4</sub> per million parts by weight COCl<sub>2</sub>, or less) even at a temperature of 300°C. Preferably, the reaction temperature and the carbon are chosen to provide phosgene which contains less than about 250 ppm by weight of carbon tetrachloride; and more preferably, are chosen to provide phosgene which contains less than about 100 ppm by weight of carbon tetrachloride, based upon phosgene. Of note are embodiments where the reaction time and temperature are controlled to provide a carbon tetrachloride concentration of about 100 ppm or less based upon the total product stream.

Without further elaboration, it is believed that one skilled in the art can, using the description herein, utilize the present invention to its fullest extent. The following specific embodiments are, therefore, to be construed as merely illustrative, and does not constrain the remainder of the disclosure in any way whatsoever.

### EXAMPLES

#### General Catalyst Testing Procedure

A 1/2" (12.7 mm) O.D. x 15" (381 mm) Inconel™ 600 nickel alloy tube containing a 100 mesh (0.015 mm) Monel™ nickel alloy screen was used as the reactor. The reactor was charged with about 2.5 mL to about 8 mL of carbon catalyst and heated to 300°C. This was the temperature used for all the examples.

A 1:1 molar ratio mixture of carbon monoxide and chlorine was passed over the catalyst. The contact times were between 8 to 12 seconds. The experimental results are shown in Table 1.

The comparative examples were done in the same way as described above. The results are shown in Table A.

#### General Analytical Procedure

The reactor effluent was sampled on-line with a Hewlett Packard HP 5890 gas chromatograph using a 105 m long, 0.25 mm I.D. column containing Restak™ RTX-1 Crossbond 100% dimethyl polysiloxane. Gas chromatographic conditions were 50°C for 10 minutes followed by temperature programming to 200°C at a rate of 15°C/minute. The smallest amount of carbon tetrachloride that could be quantitatively identified by gas chromatography was about 40 ppm by weight. For greater sensitivity an on line mass spectrometer detector was used and calibrated to determine concentrations of less than 40 ppm.

The BET surface area, pore volumes and pore distributions were obtained using a Micromeritics ASAP 2400 instrument.

### Thermal Analysis Procedure

Thermal gravimetric analysis (TGA) was done using a TA Instruments analyzer. The TGA experiments were done in air at a flow rate of 80 mL/min. The carbon sample was heated in air for the following times and temperatures;  
 5 125°C for 30 minutes, 200°C for 30 minutes, 300°C for 30 minutes, 350°C for 45 minutes, 400°C for 45 minutes, 450°C for 45 minutes and finally at 500°C for 30 minutes. The weight loss was measured at each interval and finally after completion of the heating cycle. The percentage weight loss after completion of the heating cycle at 500°C is shown in the tables.

### 10 Legend

#### Carbon Sample

- A. High surface area coconut shell carbon, Calsicat
- B. Partially graphitized carbon, Englehard
- C. 1/16" (1.6 mm) graphite carbon, Englehard
- 15 D. Type X-BCP proprietary carbon, Calgon Carbon Corp.
- R. GRC-11 proprietary carbon, Calgon Carbon Corp.
- S. Centaur proprietary carbon, Calgon Carbon Corp.
- T. Coconut shell carbon type 507, Barnebey & Sutcliffe Corp.

TABLE I

Ex.	Carbon Sample	CCl <sub>4</sub> Conc. <sup>1</sup> ppm	TGA Wt. Loss <sup>2</sup> wt. %	Active Metal Content <sup>3</sup> ppm	Fe Content ppm	Surface Area m <sup>2</sup> /g	Total Pore Volume cc/g	Micro-Pore Volume cc/g	Micro Macro Pore Ratio
1	A	330	15.39	2050	153	1661	0.81	0.61	3.1
2	B	<12	4.31	4580	3000	836	0.44	0.26	1.4
3	C	<8	2.18	2470	1000	633	0.39	0	0
4	D	90	11.19	13,300	1900	1279	0.64	0.41	1.8

<sup>1</sup>By weight as ppm of the COCl<sub>2</sub> product. The values shown are averages taken over 7 hours and are high-end estimates

<sup>2</sup>The carbon sample was heated in air for the following times and temperatures: 125°C for 30 minutes, 200°C for 30 minutes, 300°C for 30 minutes, 350°C for 45 minutes, 400°C for 45 minutes, 450°C for 45 minutes and finally at 500°C for 30 minutes. The wt. loss recorded occurred between 125 and 500°C

<sup>3</sup>Active metals consist of transition metals of groups 3 to 10, boron, aluminum and silicon

COMPARATIVE EXAMPLESTABLE A

Ex.	Carbon Sample	CCl <sub>4</sub> Conc. <sup>1</sup> ppm	TGA Wt. Loss <sup>2</sup> wt. %	Active Metal Content <sup>3</sup> ppm	Fe Content ppm	Surface Area m <sup>2</sup> /g	Total Pore Volume cc/g	Micro-Pore Volume cc/g	Micro Macro Pore Ratio
A	R	480	88.2	1520	130	835	0.40	0.36	9.0
B	S	790	59.9	21,100	1900	708	0.35	0.30	6.0
C	T	490	89.8	4900	360	1012	0.50	0.43	6.1

<sup>1</sup>By weight as ppm of the COCl<sub>2</sub> product. The values shown are averages taken over 7 hours and are high-end estimates

<sup>2</sup>The carbon sample was heated in air for the following times and temperatures: 125°C for 30 minutes, 200°C for 30 minutes, 300°C for 30 minutes, 350°C for 45 minutes, 400°C for 45 minutes, 450°C for 45 minutes and finally at 500°C for 30 minutes. The wt. loss recorded occurred between 125 and 500°C

<sup>3</sup>Active metals consist of transition metals of groups 3 to 10, boron, aluminum and silicon

CLAIMS

1. A process for producing phosgene, comprising  
contacting a mixture comprising carbon monoxide and chlorine  
with carbon which (1) has a micropore to macropore ratio of 3.5 or less; (2) loses  
5 about 16% of its weight, or less, in the WVC Temperature Test; and (3) has a  
surface area of at least 10 m<sup>2</sup>/g.
2. The process of Claim 1 where the contact is at a temperature of about  
300°C, or less.
3. A process for producing phosgene, comprising contacting a mixture  
10 comprising carbon monoxide and chlorine with carbon which (1) has a micropore  
to macropore ratio of 3.5 or less; (2) loses about 16% of its weight, or less, in the  
WVC Temperature Test; (3) has a surface area of at least 10 m<sup>2</sup>/g; and (4) has an  
active metal content of 1000 ppm or more.
4. The process of Claim 3 where the contact is at a temperature of about  
15 300°C, or less.
5. The process of Claim 4 wherein the active metal content of the carbon  
is 2000 ppm or more.
6. The process of Claim 5 wherein the carbon surface area is greater than  
about 100 m<sup>2</sup>/g.
- 20 7. The process of Claim 6 wherein the micropore to macropore ratio in  
the carbon is 2.0, or less.
8. The process of Claim 7 wherein the carbon loses about 5% of its  
weight or less in the WVC Temperature Test.

## INTERNATIONAL SEARCH REPORT

Internat'l Application No

PCT/US 97/22903

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C01B31/28

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	WO 97 30932 A (E.I. DU PONT DE NEMOURS) 28 August 1997 see claim 1 ---	1
A	DATABASE WPI Section Ch, Week 9414 Derwent Publications Ltd., London, GB; Class A41, AN 90-054036 XP002063928 & JP 06 029 129 B (IDEMITSU PETROCHEM CO) , 20 April 1994 cited in the application see abstract ---	1
A	DE 33 27 274 A (BAYER AG) 7 February 1985 cited in the application see claim 1 -----	1



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

30 April 1998

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Information on patent family members

International Application No

PCT/US 97/22903

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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DE 3327274 A	07-02-85	BR 8403747 A	02-07-85
		CA 1236115 A	03-05-88
		EP 0134506 A	20-03-85
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		US 4764308 A	16-08-88

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#### DETAILED DESCRIPTION

5 The present invention relates to improving the production of phosgene produced by contacting carbon monoxide and chlorine with carbon. The improvement can be employed in connection with any of those carbon-based processes used commercially or described in the art (e.g., those processes disclosed in U.S. Patent Nos. 4,231,959 and 4,764,308).

10 Phosgene is commercially manufactured by passing carbon monoxide and chlorine over activated carbon. The reaction is strongly exothermic and is usually done in multitubular reactors to more effectively control the reaction temperature. Carbon monoxide is typically added in at least a stoichiometric amount (often in stoichiometric excess) to minimize the free chlorine content of the phosgene product.

15 As used in connection with this invention, the term "active metals" means metals included in the group consisting of transition metals of groups 3 to 10, boron, aluminum and silicon.

The carbon materials useful as catalysts for this invention are porous (i.e., a surface area of at least 10 m<sup>2</sup>/g) and contain both micropores and macropores.

20 As used in connection with this invention, the term "micropore" means a pore size of 20 Å (2 nm) or less and the term "macropore" means a pore size of greater than 20 Å (2 nm). The total pore volume and the pore volume distribution can be determined by mercury porosimetry. The micropore volume (cc/g) is subtracted from the total pore volume (cc/g) to determine the macropore volume. The ratio

25 of micropores to macropores is then easily calculated. The carbons used for this process have a micropore to macropore ratio of less than 3.5, preferably 2.0 or less.

The carbons used for the process of this invention also exhibit substantial weight stability when heated in air. More particularly, when heated in air at

30 125°C for 30 minutes, followed by heating at 200°C for 30 minutes, followed by heating at 300°C for 30 minutes, followed by heating at 350°C for 45 minutes, followed by heating at 400°C for 45 minutes, followed by heating at 450°C for 45 minutes and finally followed by heating at 500°C for 30 minutes, the carbons employed for the process of this invention lose about 16% of their weight, or less.

35 This sequence of time and temperature conditions for evaluating the effect of heating carbon samples in air is defined herein as the "WVC Temperature Test". The WVC Temperature Test may be run using thermal gravimetric analysis (TGA). Carbons which when subjected to the WVC Temperature Test lose about 16% of their weight, or less, are considered to be advantageously oxidatively

stable. Preferably the weight loss in the WVC Temperature Test is 10% or less, more preferably 5% or less.

Low active metal content carbons can be used to achieve low carbon tetrachloride formation (see International Application No. PCT/US96/17526).

5 Low active metal carbons include three dimensional matrix porous carbonaceous materials. For example, the porous carbonaceous materials of Examples C and D in International Application No. PCT/US96/17526 have been measured to have total pore volumes of about 0.58 and 0.90 cc/g, respectively, and micropore to macropore ratios of about zero. Three dimensional matrix porous carbonaceous  
10 materials are described in U.S. Patent No. 4,978,649, which is hereby incorporated by reference herein in its entirety. Of note are three dimensional matrix carbonaceous materials which are obtained by introducing gaseous or vaporous carbon-containing compounds (e.g., hydrocarbons) into a mass of granules of a carbonaceous material (e.g., carbon black); decomposing the carbon-  
15 containing compounds to deposit carbon on the surface of the granules; and treating the resulting material with an activator gas comprising steam to provide a porous carbonaceous material. A carbon-carbon composite material is thus formed.

We have, however, discovered that when the above described micropore to  
20 macropore ratios and weight stability criteria are satisfied, then the carbon can contain 1000 ppm or greater by weight of active metals. More suprisingly, even the iron content can be greater than 1000 ppm by weight. Iron is known to accelerate carbon tetrachloride formation. Of note are embodiments where active metals are 2000 ppm or more.

25 Carbon from any of the following sources are useful for the process of this invention; wood, peat, coal, coconut shells, bones, lignite, petroleum-based residues and sugar; provided that they are treated, if necessary, to reduce the micropore volume. Commercially available carbons which may be used in this invention include those sold under the following trademarks: Calgon X-BCP and  
30 Calsicat. The carbon support can be in the form of powder, granules, or pellets, or the like.

The carbon surface area as determined by BET measurement is preferably greater than about 100 m<sup>2</sup>/g and more preferably greater than about 300 m<sup>2</sup>/g (e.g., from 550 to 1000 m<sup>2</sup>/g). Typically, surface areas are 2000 m<sup>2</sup>/g or less.

35 It is known from dissociation equilibria that at 100°C, phosgene contains about 50 ppm chlorine; and that at 200°C, about 0.4%, at 300°C, about 5% and at 400°C about 20% of the phosgene is dissociated into carbon monoxide and chlorine. Also, the higher the reaction temperature, the more carbon tetrachloride is generally produced. Accordingly, the temperature of the reaction is generally

about 300°C, or less (e.g., in the range of from 40°C to 300°C). Preferably, the temperature of the process is from about 50°C to 200°C; more preferably from about 50°C to 150°C. The phosgene produced by the process of this invention typically contains about 350 ppm by weight or less of carbon tetrachloride, based upon phosgene (i.e., 350 parts by weight  $\text{CCl}_4$  per million parts by weight  $\text{COCl}_2$ ,  
5 or less) even at a temperature of 300°C. Preferably, the reaction temperature and the carbon are chosen to provide phosgene which contains less than about 250 ppm by weight of carbon tetrachloride; and more preferably, are chosen to provide phosgene which contains less than about 100 ppm by weight of carbon  
10 tetrachloride, based upon phosgene. Of note are embodiments where the reaction time and temperature are controlled to provide a carbon tetrachloride concentration of about 100 ppm or less based upon the total product stream.

Without further elaboration, it is believed that one skilled in the art can, using the description herein, utilize the present invention to its fullest extent. The  
15 following specific embodiments are, therefore, to be construed as merely illustrative, and does not constrain the remainder of the disclosure in any way whatsoever.

### EXAMPLES

#### General Catalyst Testing Procedure

20 A 1/2" (12.7 mm) O.D. x 15" (381 mm) Inconel™ 600 nickel alloy tube containing a 100 mesh (0.015 mm) Monel™ nickel alloy screen was used as the reactor. The reactor was charged with about 2.5 mL to about 8 mL of carbon catalyst and heated to 300°C. This was the temperature used for all the examples.

A 1:1 molar ratio mixture of carbon monoxide and chlorine was passed  
25 over the catalyst. The contact times were between 8 to 12 seconds. The experimental results are shown in Table 1.

The comparative examples were done in the same way as described above. The results are shown in Table A.

#### General Analytical Procedure

30 The reactor effluent was sampled on-line with a Hewlett Packard HP 5890 gas chromatograph using a 105 m long, 0.25 mm I.D. column containing Restak™ RTX-1 Crossbond 100% dimethyl polysiloxane. Gas chromatographic conditions were 50°C for 10 minutes followed by temperature programming to 200°C at a rate of 15°C/minute. The smallest amount of carbon tetrachloride that could be  
35 quantitatively identified by gas chromatography was about 40 ppm by weight. For greater sensitivity an on line mass spectrometer detector was used and calibrated to determine concentrations of less than 40 ppm.

The BET surface area, pore volumes and pore distributions were obtained using a Micromeritics ASAP 2400 instrument.

### Thermal Analysis Procedure

Thermal gravimetric analysis (TGA) was done using a TA Instruments analyzer. The TGA experiments were done in air at a flow rate of 80 mL/min.

The carbon sample was heated in air for the following times and temperatures;

5 125°C for 30 minutes, 200°C for 30 minutes, 300°C for 30 minutes, 350°C for 45 minutes, 400°C for 45 minutes, 450°C for 45 minutes and finally at 500°C for 30 minutes. The weight loss was measured at each interval and finally after completion of the heating cycle. The percentage weight loss after completion of the heating cycle at 500°C is shown in the tables.

10 Legend

## Carbon Sample

- 15      A. High surface area coconut shell carbon, Caldicat  
B. Partially graphitized carbon, Englehard  
C. 1/16" (1.6 mm) graphite carbon, Englehard  
D. Type X-BCP proprietary carbon, Calgon Carbon Corp.  
R. GRC-11 proprietary carbon, Calgon Carbon Corp.  
S. Centaur proprietary carbon, Calgon Carbon Corp.  
T. Coconut shell carbon type 507, Barnebey & Sutcliffe Corp.

TABLE 1

Ex.	Carbon Sample	CCl <sub>4</sub> Conc. <sup>1</sup> ppm	TGA Wt. Loss <sup>2</sup> wt. %	Active Metal Content <sup>3</sup> ppm	Fe Content ppm	Surface Area m <sup>2</sup> /g	Total Pore Volume cc/g	Micro-Pore Volume cc/g	Micro Macro Pore Ratio
1	A	330	15.39	2050	153	1661	0.81	0.61	3.1
2	B	<12	4.31	4580	3000	836	0.44	0.26	1.4
3	C	<8	2.18	2470	1000	633	0.39	0	0
4	D	90	11.19	13,300	1900	1279	0.64	0.41	1.8

<sup>1</sup> By weight as ppm of the COCl<sub>2</sub> product. The values shown are averages taken over 7 hours and are high-end estimates

<sup>2</sup>The carbon sample was heated in air for the following times and temperatures: 125°C for 30 minutes, 200°C for 30 minutes, 300°C for 30 minutes, 350°C for 45 minutes, 400°C for 45 minutes, 450°C for 45 minutes and finally at 500°C for 30 minutes. The wt. loss recorded occurred between 125 and 500°C

<sup>3</sup>Active metals consist of transition metals of groups 3 to 10, boron, aluminum and silicon.

COMPARATIVE EXAMPLESTABLE A

Ex.	Carbon Sample	CCl <sub>4</sub> <sup>1</sup> Conc. ppm	TGA Wt. Loss <sup>2</sup> wt. %	Active Metal Content <sup>3</sup> ppm	Fe Content ppm	Surface Area m <sup>2</sup> /g	Total Pore Volume cc/g	Micro- Pore Volume cc/g	Micro Macro Pore Ratio
A	R	480	88.2	1520	130	835	0.40	0.36	9.0
B	S	790	59.9	21,100	1900	708	0.35	0.30	6.0
C	T	490	89.8	4900	360	1012	0.50	0.43	6.1

<sup>1</sup>By weight as ppm of the COCl<sub>2</sub> product. The values shown are averages taken over 7 hours and are high-end estimates

<sup>2</sup>The carbon sample was heated in air for the following times and temperatures: 125°C for 30 minutes, 200°C for 30 minutes, 300°C for 30 minutes, 350°C for 45 minutes, 400°C for 45 minutes, 450°C for 45 minutes and finally at 500°C for 30 minutes. The wt. loss recorded occurred between 125 and 500°C

<sup>3</sup>Active metals consist of transition metals of groups 3 to 10, boron, aluminum and silicon

CLAIMS

1. A process for producing phosgene comprising  
contacting a mixture comprising carbon monoxide and chlorine  
with carbon which (1) has a micropore to macropore ratio of 3.5 or less; (2) loses  
5 about 16% of its weight, or less, in the WVC Temperature Test; and (3) has a  
surface area of at least 10 m<sup>2</sup>/g.
2. The process of Claim 1 where the contact is at a temperature of about  
300°C, or less.
3. A process for producing phosgene, comprising contacting a mixture  
10 comprising carbon monoxide and chlorine with carbon which (1) has a micropore  
to macropore ratio of 3.5 or less; (2) loses about 16% of its weight, or less, in the  
WVC Temperature Test; (3) has a surface area of at least 10 m<sup>2</sup>/g; and (4) has an  
active metal content of 1000 ppm or more.
4. The process of Claim 3 where the contact is at a temperature of about  
15 300°C, or less.
5. The process of Claim 4 wherein the active metal content of the carbon  
is 2000 ppm or more.
6. The process of Claim 5 wherein the carbon surface area is greater than  
about 100 m<sup>2</sup>/g.
- 20 7. The process of Claim 6 wherein the micropore to macropore ratio in  
the carbon is 2.0, or less.
8. The process of Claim 7 wherein the carbon loses about 5% of its  
weight or less in the WVC Temperature Test.

# INTERNATIONAL SEARCH REPORT

Intern al Application No

PCT/US 97/22903

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 C01B31/28

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	WO 97 30932 A (E.I. DU PONT DE NEMOURS) 28 August 1997 see claim 1 ---	1
A	DATABASE WPI Section Ch, Week 9414 Derwent Publications Ltd., London, GB; Class A41, AN 90-054036 XP002063928 & JP 06 029 129 B (IDEMITSU PETROCHEM CO) , 20 April 1994 cited in the application see abstract ---	1
A	DE 33 27 274 A (BAYER AG) 7 February 1985 cited in the application see claim 1 -----	1

☐

Further documents are listed in the continuation of box C.

☒

Patent family members are listed in annex.

° Special categories of cited documents :

\*A\* document defining the general state of the art which is not considered to be of particular relevance

\*E\* earlier document but published on or after the international filing date

\*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

\*O\* document referring to an oral disclosure, use, exhibition or other means

\*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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\*&\* document member of the same patent family

Date of the actual completion of the international search

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 97/22903

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		CA 1236115 A	03-05-88
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